UNIVERSITI PUTRA MALAYSIA

IMPROVEMENT STUDIES ON MANUFACTURING OPERATION DESIGN FOR MINT PILOT PLANT

ROSLI DARMAWAN

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By

ROSLI DARMAWAN

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ROSLI BIN DARMAWAN

January 2002

Chairperson: **Napsiah Ismail, Ph. D.**

Faculty: **Faculty of Engineering**

The difficulty faced by MINT's researchers during the transformation process from laboratory scale plant to pilot scale plant was investigated. Analysis was carried out on the methodology used, plant development stages and the plant characteristics in order to identify the problem areas and weaknesses. Improvement effort on the pilot plant design methodology, based on Manufacturing Sytem design techniques was carried out. The effectiveness of the improvement on the design methodology was analysed by comparing the plants' design parameters resulted from the existing methodology with that of the proposed methodology. Further evaluation on the plants operational performance was conducted through the plant operational simulation. Both plants were modelled using a discrete-event simulation software.

The model was validated by comparing the results of the simulation with the actual operational data of the existing plant. Comparison from the design parameters and plant operational performance indicated that the proposed new plant performed better than the existing plant. The proposed plant has higher plant capacity; requires less floor area, capital cost and running cost; better machine, space and labour utilisation; less throughput time and less production lead time. This result is a manifestation of the plant design, which indicates that the proposed plant was designed better than the existing plant. Thus, with this proposed design methodology, MINT's researchers will be able to design a better pilot plant and enable them to continue further with their research activities.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains

KAJIAN PENINGKATAN KE ATAS REKABENTUK OPERASI PEMBUATAN UNTUK LOJI PERINTIS MINT

Oleh

ROSLI BIN DARMAWAN

Januari 2002

Pengerusi: **Napsiah Ismail, Ph.D.**

Fakulti: **Kejuruteraan**

Penyelidikan telah dijalankan ke atas masalah yang dihadapi oleh para penyelidik MINT sewaktu proses peralihan dari loji skala makmal ke loji skala perintis. Analisa telah dilakukan ke atas kaedah yang digunakan, proses pembangunan loji dan ciri-ciri loji untuk mengenalpasti masalah dan kelemahan sedia ada. Usaha-usaha peningkatan ke atas kaedah rekabentuk loji perintis telah dilaksanakan berdasarkan dari teknik-teknik rekabentuk Sistem Pembuatan. Perbandingan telah dibuat ke atas parameter rekabentuk hasil dari kaedah sedia ada dan kaedah yang dicadangkan untuk menilai keberkesanannya. Penilaian lanjut ke atas prestasi operasi kedua-dua loji telah dilakukan melalui proses simulasi. Kedua-dua loji telah dimodel menggunakan pekakasan simulasi jenis peristiwa-diskret. Model simulasi telah disemak kesahihannya dengan membandingkan keputusan

simulasi dengan rekod operasi sebenar loji sedia ada. Perbandingan parameter rekabentuk dan prestasi operasi loji menunjukkan bahawa loji cadangan beroperasi lebih baik dari loji sedia ada. Loji cadangan mempunyai kapasiti lebih tinggi; memerlukan ruang lantai, kos modal dan kos operasi yang rendah; tahap penggunaan mesin, ruang dan tenaga kerja yang lebih baik; daya pemerosesan dan masa lopor pengeluaran yang kurang. Keputusan ini adalah satu manifestasi rekabentuk loji yang menunjukkan bahawa loji cadangan telah direkabentuk lebih baik dari loji sedia ada. Dengan adanya kaedah rekabentuk cadangan ini, para penyelidik MINT akan dapat merekabentuk loji perintis dengan lebih baik dan dapat meneruskan aktiviti-aktivi penyelidikan mereka dengan lebih lanjut lagi.

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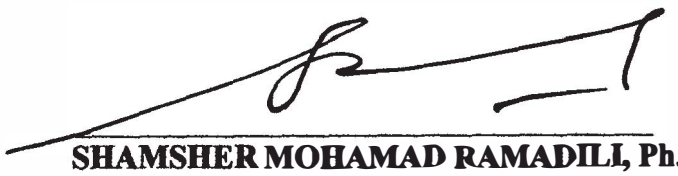
I certify that an Examination Committee met on 25th January, 2002 to conduct the final examination of Rosli bin Darmawan, on his Master of Science thesis entitled "Improvement Studies on Manufacturing Operation Design for MINT Pilot Plant" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of Examination Committee are as follows:

HASAN YUDIE SASTRA, Ph.D.
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

NAPSIAH BT ISMAIL, Ph.D.
Faculty of Engineering
Universiti Putra Malaysia
(Member)

ZULKIFLLE LEMAN.
Faculty of Engineering
Universiti Putra Malaysia
(Member)

MEGAT MOHAMAD HAMDAN MEGAT AHMAD, Ph.D.
Faculty of Engineering
Universiti Putra Malaysia
(Member)



SHAMSHER MOHAMAD RAMADILI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 3 APR 2002

The thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia.

Date:

DECLARATION

I hereby declare that the thesis is based on my origional work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any degree at UPM or other institutions.

ROSLI BIN DARMAWAN

Date: 3-4-2002

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LIST OF ABBBREVIATIONS

ASME	American Society of Mechanical Engineers
EFB	Empty Fruit Bunch
FEFB	Fermented Empty Fruit Bunch
FP	Final Processing
IMP2	Second Industrial Master Plan
INOC	Inoculation
IOPF	Inoculated Oil Palm Fibre
IS	Incubation Section
KBS	Knowledge Base System
MHS	Material Handling System
MINT	Malaysian Institute for Nuclear Technology Research
MITI	Ministry of International Trade and Industry
OPF	Oil Palm Fibre
PVC	Poly Vinyl Chloride
R&D	Research and Development
REL	Relationship
RM7	Rancangan Malaysia ke Tujuh
SLP	Systematic Layout Planning
SOPF	Sterilised Oil Palm Fibre
SPL1	Substrate Preparation Line 1
SPL2	Substrate Preparation Line 2
WIP	Work in Process

CHAPTER ONE

INTRODUCTION

1.1 General Background

Malaysian Institute for Nuclear Technology Research (MINT) conducts research and development (R&D) programmes in nuclear and related technology. Since its establishment in 1972 the R&D activities have been focused on basic research in nuclear science and the customisation of nuclear technology in Malaysia. The activities were focused on bringing the developed nuclear technology from abroad and customised them to suit local needs (MINT, 1996).

By the end of 1980's, MINT started to venture into the generation and development of new products and processes, either in collaboration with the private sectors or with the international and local R&D institutions. This shift is in line with the objective of the Second Industrial Master Plan (IMP2) to encourage R&D growth in Malaysia (MITI, 1998).

MINT Technology Park was launched in 1998 to support the development of this new R&D activities. It functions as a centre to strengthen MINT's capability in the development of the new technology from laboratory scale to the design of pilot plant, and finally for commercialisation process. One of the pilot plant developed in MINT Technology Park is Sterifeed pilot plant (MINT, 1998).

1.2 Sterifeed Pilot Plant

Sterifeed pilot plant is the outcome of an almost ten years of extensive research and development on the upgrading of oil palm empty fruit bunch (EFB) to ruminant feed. With the idea of recycling, green technology and zero waste concept, the EFB has been identified to have huge potential to be converted into a good quality animal feed product (Alang, 1998).

By adopting the sterilisation and fermentation technology, the EFB is converted into pallet form of ruminant feed which have nutritional value and digestibility comparable to Oil Palm Frond (OPF) silage diet. The sterilisation process is for the elimination of any toxic content in EFB, whereas the fermentation with pleurotus sajor-caju (a mushroom species) is to reduce fibre content and increase protein content in EFB. The name 'Sterifeed' comes from the phrase 'sterillised feed' indicating the technology being used for the product (Awang et al., 1998).

1.3 Problem Definition

As mentioned in section 1.1, the main activities in MINT Technology Park is the development and evaluation process of the discovered technology from laboratory scale to pilot plant, and finally to the commercialisation stage. The first phase of this development process is the design of pilot plant. Sterifeed pilot plant was designed

and developed by a group of MINT's researchers after the completion of laboratory scale studies.

The evaluation made by Sterifeed plant's researchers showed that the plant failed to produce the intended production volume of 15,000 kg/month. The plant only produced 700 kg/month of animal feed, which is only about 4.6% of the intended capacity. The result also showed that the plant has serious bottleneck problems in its production lines due to unbalanced capacity between its workstations (Awang et al., 1998). Discussion with Sterifeed plant's researchers revealed that they faced difficulties during the design of the pilot plant. They do not have any prior experience and knowledge in the design of pilot plant. The pilot plant was designed based on trial and error without reference to any manufacturing plant design method.

Therefore, the above phenomenon needs further investigation to identify the problems and difficulties faced during the design process of Sterifeed pilot plant. This investigation will open opportunities for improvement of the situation and finally to come up with the solutions.

1.4 Objectives

The objectives of this study are:

a) To study and identify the methodology used by Sterifeed plant's researchers during transformation process from laboratory scale to pilot plant.

b) To evaluate and compare the methodology used during transformation process with manufacturing plant design techniques.

c) To propose a methodology for a more successful transformation process from laboratory scale to pilot plant.

1.5 Project Scope

The scope of the project is limited to a case study of the Sterifeed pilot plant, which is located in MINT Technology Park. This plant is a processing plant which transforms oil palm fibre (OPF) into animal feed product called Sterifeed.

The investigation is focused on the *transformation process* from laboratory scale experiment into pilot plant. This process is sometimes described as the *scaling-up process* from laboratory scale to pilot plant scale (Barr et al.,1994). The process involves the design of pilot plant based on the findings from laboratory scale experiments. Therefore, the transformation process may also be referred to as *the design of pilot plant*.

1.6 Significance of the Study

The study will be able to identify the weaknesses of the current methodology used by MINT's researchers in designing their pilot plant. A proposal on a new and improved

design methodology will be able to help the researchers to come up with a better plant design. A better plant design with a reasonably good pilot plant operation will enable the researchers to focus on the optimisation process of the pilot plant and to continue further with the R&D of the product.

CHAPTER TWO

LITERATURE REVIEW

2.1 General Introduction

Pilot plant is defined as a manufacturing plant which operates at a smaller capacity of the actual plant. It also known as an experimental plant which functions as a testing ground to establish the optimum process and to study critical operational data which will be used to design the full-scale plant (Simdean, 1998).

The study on pilot plant design can be categorised into a few different scopes. There are studies which focus on specific aspects of a pilot plant design. Hills et al. (1993) focused on plant layout design for made-to-order products. His study combined an algorithm method with a knowledge based system (KBS) to come up with a near-optimal layout design. The algorithm requires the input from the KBS in order to solve the design problem. With continuous iteration of the algorithm, together with the set criterion, a near-optimal layout solution is obtained. The layout is then, ready to be converted into a more typical layout format for the final layout design. Lyu (1997) proposed an algorithm technique for assembly line balancing problem. The proposed algorithm is based on the single-run optimisation approach which is applied to find the optimal parameters of the model. This approach integrates a perturbation analysis algorithm, to estimate the derivatives of the model, and a stochastic approximation algorithm, to update its estimate for optimal solution of the

problem. The optimal assembly line is obtained through iterative process of both algorithms after the model met its predetermined objectives. Herrman et al. (1995) studied the combination of network design model and heuristic method for material handling flow design. The network design model incorporates critical parameters such as fixed costs, operating costs and aisle capacities which are formulated in several governing equations. The equations are derived from Cartesian grid nodes constructed from the actual plant layout. The equation are solved using heuristic algorithm developed for the model to obtain a near-optimal solution and to assess solution quality. All of these studies are too specific and quite complicated to be used by MINT's research scientists. The study by Bar et al. (1994) brought together interdisciplinary skills from manufacturing engineering, quality engineering, development, research and consultants to focus on a given problem and attempt to hypothesise or model the problem in a laboratory scale plant. Although this approach will be able to analyse and solve many aspects of pilot plant design, however it requires the involvement of many parties from different organisations and is only practical for a national scale development project.

The most common practice in pilot plant design is using the same methodology used for the design of a full scale manufacturing plant. The only difference is that the pilot plant is designed as a scale down version of the actual manufacturing plant. These methods adopt basic techniques and cover all aspects of a manufacturing operation design (Mc Kenna, 1999). Thus, for this study, the basic methodology of manufacturing operation design was used since it covers all aspects of a

manufacturing plant design, uses simple design techniques and suitable for the initial development effort made by MINT's researchers.

2.2 Manufacturing Operation Design

The term *manufacturing* may be defined as 'the production of tangible finished products that can be numbered, stored and consumed at a later date' (Monks, 1987). It may also be described in comparison with the service operation where the manufacturing operations have low customer contact, long response time, large facilities and capital intensive. Whereas service operations produce products that are intangible, perishable, cannot be stored, have high customer contact, short response time, small facilities and a labor intensive operation (Krajewski et al., 1998).

The definition of *operation* may be as simple as 'the conversion of input into output ' (Weiss et al.,1991) or 'the process whereby resources flowing within a defined system, are combined and transformed into value added products' (Monks,1987).

Therefore, *manufacturing operation design* may be defined as the planning of the process that combine and transform resources into value added finished products that are tangible, durable, can be stored and consumed at a later date.